

A linear micro-positioning actuator for ambient and cryogenic operation

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Introduction

Many space systems, especially those of gossamer construction, must rely on active control to maintain required dimensional stability. In this paper we describe a newly invented micropositioning actuator that could find many applications in such systems. The original motivation was for the positioning system in the University of Arizona's MARS mirror system (Membrane with Active Rigid support)¹. In this concept, a thin mirror with the correct figure but too flexible to hold its shape is rigidly attached at many points to a stiff carbon composite structure. Because the structure is not stable at optical tolerance levels against thermal or other perturbations, the two-dimensional array of attaching actuators require occasional active adjustment to maintain the mirror shape. The NMSD prototype currently being manufactured needed actuators with resolution of ~ 10 nm, stroke of several mm, zero hold power, mass of 50 g or less and operation at ambient and cryogenic temperatures.

Detailed description

The actuator takes the form of a shaft threaded into a nut which is impacted with a small mass to cause momentary rotation. A torsional spring restores the nut to its original position after each impact. The shaft is preloaded to obtain a particular frictional torque between the nut and shaft. The friction is set at a level that is lower than would be required to accelerate the shaft at the high initial angular acceleration of the nut on impact. As a result, the angular position of the shaft lags behind that of the nut, and the shaft advances or retreats. The torsional spring supporting the nut limits the rotational travel of the nut and returns it to its initial position. The stiffness of the torsional spring is set so that the deceleration and subsequent rotational vibrations of the nut do not result in accelerations that are greater than can be transmitted to the shaft by friction, so the shaft and nut then move as one. The advance of the shaft through the nut that occurs immediately after the impact is thereby preserved. The speed and momentum of the impacting mass can be adjusted to vary the relative motion of the shaft and nut and hence the step size. Motion in both the extension and retraction directions is obtained by using two separate impactors. No power is required to hold position, only to make step motions.

Cryogenic prototype

We have built a 50 g positioner with a 1/4-80 threaded shaft shown on the right in figure 1. Its two impactors are accelerated electro-magnetically. In operation at room temperature, the electrical energy per impact is about 2 mJ. The step size is quite repeatable, and can be varied from 10 to 100 nm by adjusting length of the current pulse from 1 to 2 msec. Operation continues reliably when the actuator is placed in a dewar at 77K. At this temperature, the pulse energy is much reduced because of much lower resistance of the magnet coils. The actuator continues to function with reduced step size for loads up to 20N. The full stroke is more than 1 cm. The second actuator in figure 1 works in the same way, but incorporates an 0-80 screw and weighs only 7 grams. At the other extreme, the principle could be applied to make beefier

actuators with hundreds of pounds of driving force, still free of hysteresis and with resolution of a few nm.

Acknowledgement

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Reference

1. J.H. Burge, J.R.P Angel, B. Cuerden, H.M. Martin, S.M. Miller and D.G. Sandler, 1998 Proc. SPIE **3356**, 690-701.

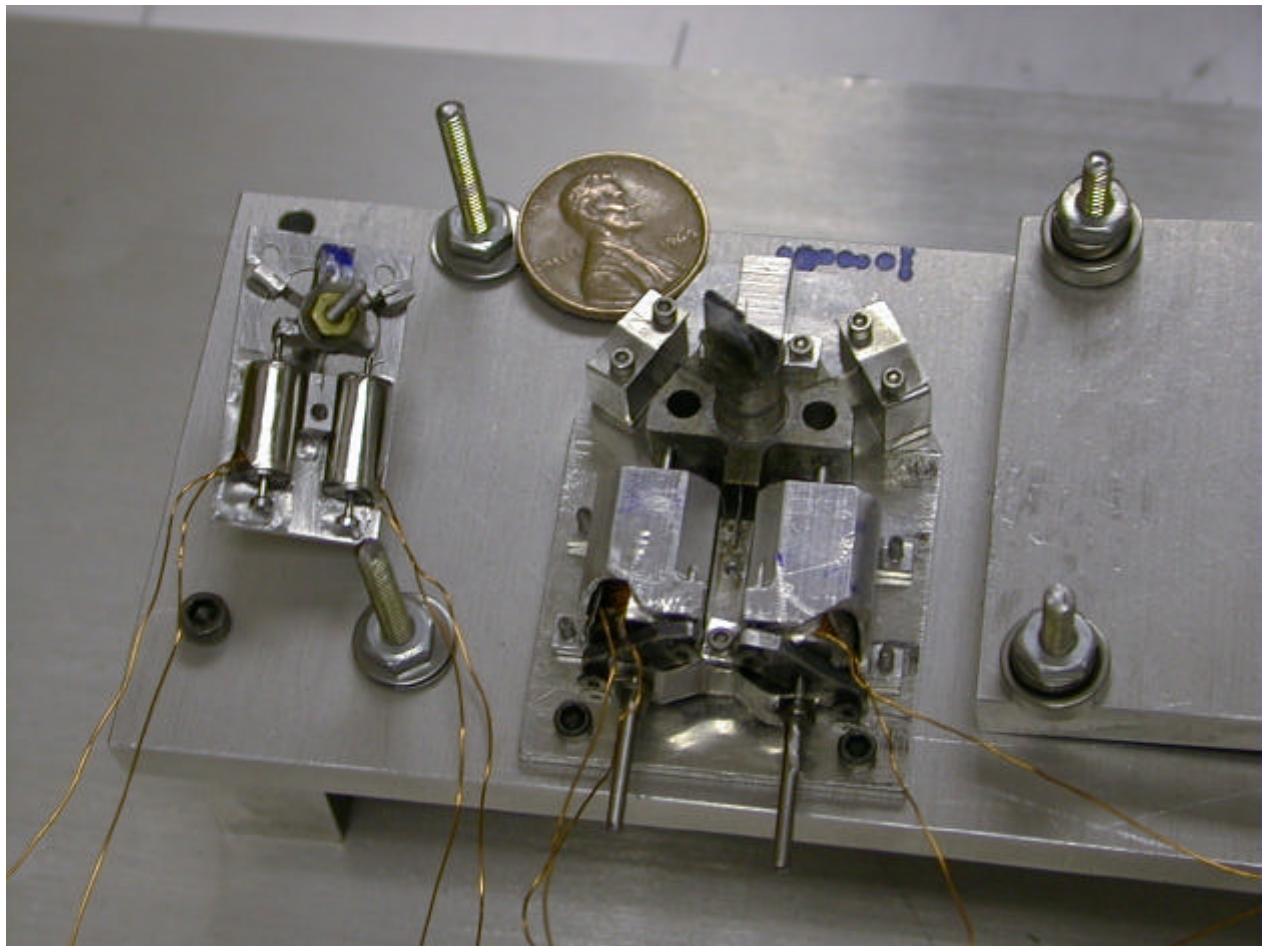


Figure 1. Two prototype actuators. The larger one on the right weighs 43 g, the left hand one 7 g.